CHAPTER 11

Skeletal Indicators of Work: Musculoskeletal, Arthritic and Traumatic Effects

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The types of bony changes studied in association with mechanical stress include: osteoarthritis, pressure facets, cortical thickness, fracture, and hypertrophy of tendinous and ligamentous attachment sites. While age is one component in the development of many of these markers, we believe that they mainly reflect the cumulative effects of mechanical stress rather than senile degeneration alone. This influence is supported by extensive experimental evidence of bone remodeling with increased osteogenesis and decreased bone resorption in response to mechanical loading (see reviews in Boyde 2003, Knüsel 2000, Wilczak and Kennedy 1998). The empirical evidence of Wolff's 1892 theory of bone transformation provides the research rationale for studies of activity-induced bone hypertrophy (Derevenski 2000; Hawkey and Merbs 1995, Weiss 2003, Wilczak 1998). In the case of osteoarthritis, which involves both cartilage and bone, current studies of repetitive loading on isolated cartilage tissue and individual chondrocytes indicate that biomechanical factors do contribute to degenerate joint disease onset, although the precise nature of the relationship has yet to be defined (Shieh and Athanasiou 2002).

It is also important to note that some researchers have argued against normal levels of habitual activity as a factor in the distribution of these markers, particularly in the case of osteoarthritis but do consider traumatic injury or extreme forms of labor plausible candidates for early and severe forms of development (Jurmain1999; Knüsel 2000). Trauma or acute stress is a generally accepted causative factor in the development of osteoarthritis, and clinical studies in sports medicine show that enthesial disorders can also be initiated by injury (Benjamin et al. 2002; Ortner 2003). There are two significant etiological possibilities in terms of assessing the labor intensity of a population: direct responses to loading that was experienced during normal levels of activity or initiation due to traumatic injury.

Skeletal indicators of work stress are of particular interest for the African Burial Ground Project (ABGP) because physical labor is the principle purpose for which Africans were enslaved. We expect a diverse expression of markers among individuals from this sample due to anticipated differences in cultural practices and genetic susceptibility, as well as variability in labor patterns. Slave labor in the city would include work in fisheries, industry, transportation, shipping, small shops, construction, and domestic work. A study of an urban enslaved population from New Orleans (1720-1810) found that skeletal indicators of labor stress were more variable than in rural enslaved, reflecting this wide range of activities (Owsley et al. 1987). While many of the urban enslaved had pronounced skeletal changes associated with manual labor, others, possibly free Blacks or domestic enslaved, exhibited very few signs of physical stress. Similar patterns should be observed in the African Burial Ground (ABG) population.

Sample Analyzed

Incidence rates for mechanical stress markers were calculated using only individuals of 15 years of age or greater. Enslaved children were often put to work at an early age, but there are several reasons to limit the analyses of markers of biomechanical stress to late adolescents and adults: 1) continuous bone remodeling associated with growth may confound the analysis; 2) stress markers can require repeated stress over a period of time to develop; and 3) most studies of occupational markers have been limited to adults and little is known about their development in subadults.

The excavated New York African Burial Ground (NYABG) remains included 419 burials; 187 individuals were suitable for this analysis. Two hundred and twenty-nine individuals were excluded because they were either less than 15 years of age, too incomplete for analysis, or fungal contamination prevented analysis. Three males with bilateral sacroiliac fusion were also excluded based on a possible differential diagnosis of a spondyloarthropathy or DISH, which can confound stress marker analyses (Arriaza 1993; Ortner 2003). Two of the excluded males were in the age range of 35 to 49 years while the third was a male in the 50+ age category. The demographic distributions of the individuals used in this portion of the study are presented in Table 11.1. Sample size for analysis of specific markers varies from these maximum numbers due to differential preservation of various skeletal elements.

Table 11.1: Demography of the Sample used in Stress Marker Analysis

Age Categories	Males	Females	Unknown sex
15-24	15	12	8
25-34	17	18	3
35-49	40	20	0
50+	16	13	0
Adult	10	15	0
Totals	98	78	11

Degenerative Changes of the Joints

Scoring

Osteoarthritis of the synovial joints was scored as changes including porosity of the articular surface, lipping at the joint margins, and eburnation or grooving of opposing surfaces. Spinal osteophytosis (spondylosis deformans) of vertebral body synchondral joints was scored based on marginal spicule (osteophyte) development. Initial analysis included a determination of severity for each type of degenerative change scored on a scale as either absent = 0, mild = 1, or moderate to severe = 2.

For osteoarthritis, a composite score for each joint or joint complex was created, which included both the individual severity scores and the type of degenerative changes. Porosity and osteophyte scores were classified as mild when one or both scores equaled 1, moderate when one score equaled a 2, or severe if both scores equaled 2. Eburnation is usually considered an end stage of cartilage breakdown and joint destruction, so its presence was always scored as severe. If more than one articular surface was present for a joint, the higher composite score was used. In some cases, such as the hands and feet, functional areas included multiple synovial joints comprising a joint complex. Osteoarthritis was assessed as present for such a region when any one of the joints showed degenerative changes. Since more than 90 percent of the sample showed identical composite osteoarthritis scores on the right and left side, no analysis of asymmetry is presented.

Results of the Vertebral Analysis

Figures 11.1 and 11.2 illustrate severe vertebral osteoarthritis and osteophytosis development. Sample sizes and the frequency of degenerative changes by sex for osteoarthritis of the vertebral synovial joints and osteophytosis of the vertebral bodies are listed in Tables 11.2 and 11.3. Since there is a known age component in the development of osteoarthritis and osteophytosis, frequencies are given with the total sample age range from 15-50+ and excluding the oldest and youngest for a sample age range of 25-49 years. Thirty-four males and twenty-nine females have evidence of osteoarthritis in at least one vertebral region. There is little evidence for sex differences in the distribution of vertebral osteoarthritis. Lumbar vertebrae show the greatest difference with 58.3 percent of females and 42.5 percent of males affected for the age range of 25-49 years, but this difference is not statistically significant (chi-square test, $p=0.22$).

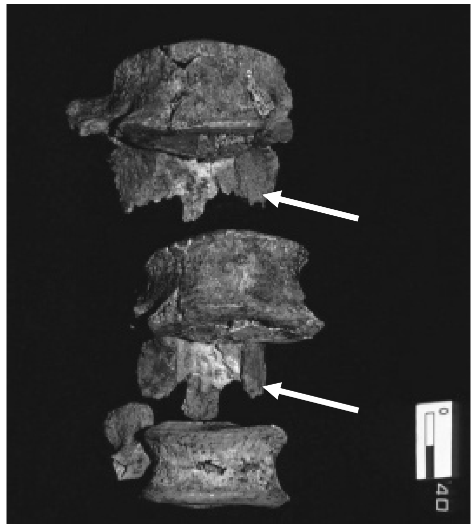

Figure 11.1: Severe osteoarthritis of the vertebral articular processes in a female aged 50-60 years old. (Burial 40)

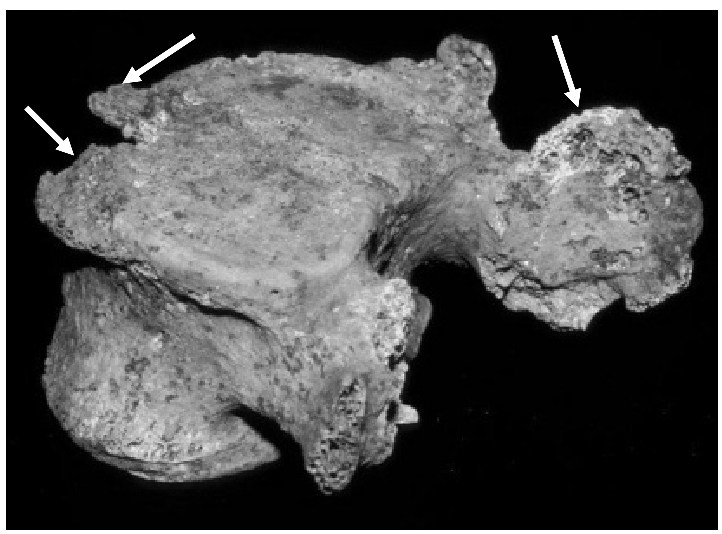

Figure 11.2: Severe osteophytosis (left arrows) and osteoarthritis (right arrow) of a lumbar vertebra in a male aged 35 - 45 years (Burial 63)

Vertebral osteophytosis is present in 23 males and 21 females in at least one vertebral region. Cervical osteophytosis rates are similar to osteoarthritis rates in individuals

25-49, but thoracic and lumbar osteophytosis occurs about half as frequently as osteoarthritis. There is no evidence for significant differences between the sexes in the rates of osteophytosis for individuals aged 25-49.

Table 11.2: Distribution of moderate to severe vertebral osteoarthritis by sex

	Males		**Females**	
Age in yrs	**# affected[1]**	**%**	**# affected[1]**	**%**
	Cervical			
25-49	11 (39)	28.2	7 (23)	30.4
15-50+	18 (59)	30.5	10 (47)	21.3
	Thoracic			
25-49	12 (30)	40.0	9 (23)	39.1
15-50+	19 (52)	36.5	13 (41)	31.7
	Lumbar			
25-49	17 (40)	42.5	14 (24)	58.3
15-50+	26 (63)	41.3	26 (45)	57.8

[1]Numbers in parentheses are sample sizes (n)

Table 11.3: Distribution of moderate to severe vertebral osteophytosis by sex

	Males		Females	
Age in yrs	**# affected[1]**	**%**	**# affected**	**%**
	Cervical			
25-49	12 (39)	30.8	6 (24)	25.0
15-50+	20 (60)	33.3	15 (47)	31.9
	Thoracic			
25-49	6 (32)	18.8	3 (22)	13.6
15-50+	13 (52)	25.0	8 (40)	20.0
	Lumbar			
25-49	7 (43)	16.3	3 (23)	13.0
15-50+	12 (68)	17.6	11 (43)	25.6

[1]Numbers in parentheses are sample sizes (n)

Comparisons among age categories and regions are most clearly seen in Figures 11.3 and 11.4. Males, females and individuals of unknown sex are combined into one sample for this analysis since neither osteophytosis nor osteoarthritis rates show significant sex differences, and sample sizes are as low as eight individuals when the sexes are considered separately by age. Total sample sizes for the individual vertebral regions by age categories range from 18 to 44 individuals. The general trend for both osteophytosis and osteoarthritis is toward increased frequencies of affected individuals with age. Nonetheless, a fairly large proportion of the youngest age group has moderate to severe degenerative changes. The most striking example is seen in osteoarthritis of the lumbar vertebrae with 45.0 percent of individuals aged 15 to 24 affected. Also in this age category, the frequency of moderate to severe cervical osteoarthritis is 11.0 percent and cervical osteophytosis is 10.5 percent.

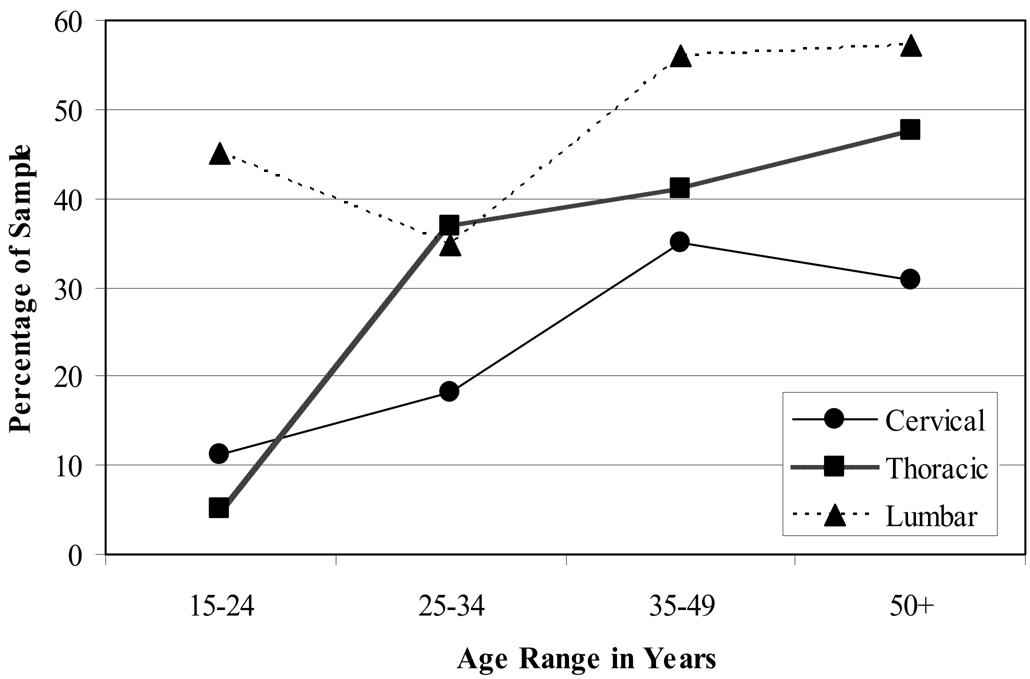

Figure 11.3: Age and incidence moderate to severe vertebral osteoarthritis

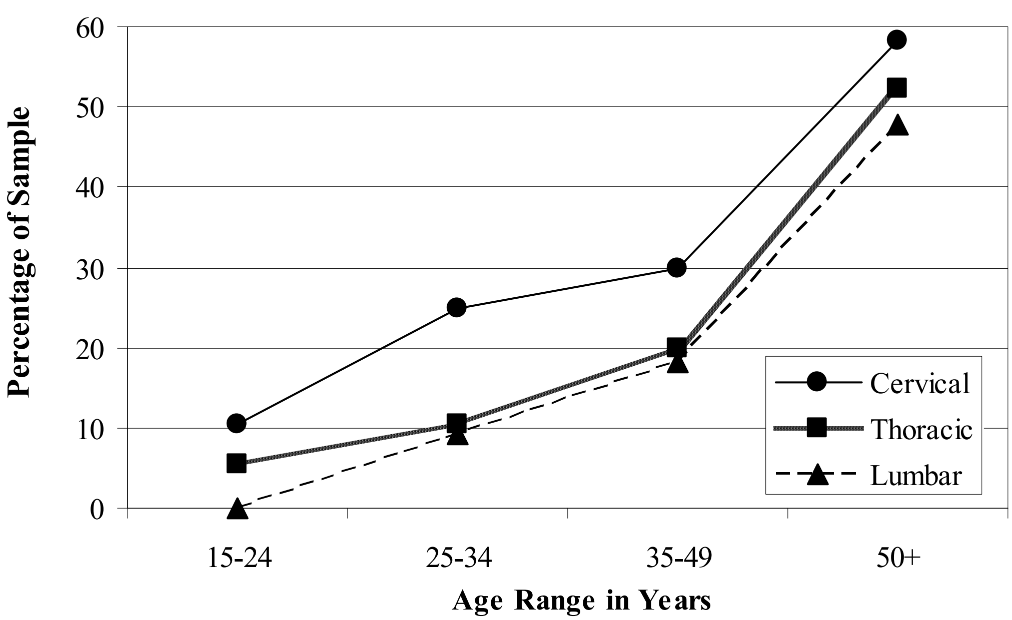

Figure 11.4: Age and incidence of moderate to severe osteophytosis.

In this sample, cervical osteophytosis is more frequent than in the thoracic and lumbar regions in all age categories (Figure 11.5). When the thirty-two cervical osteophytosis cases with preserved thoracic or lumbar vertebrae are examined individually, twenty (nine females and eleven males) or 62.5 percent do not have these severe changes in one or both of the other two vertebral regions. For these twenty cases, cervical osteoarthritis is absent in four (20 %), mild in four (20 %) and moderate to severe in twelve (60 %). The corresponding ages of these cervically affected individuals are: two, 15 to 24; four, 25-34; eight, 35 to 50; and six, 50+. By the sixth decade, 58.4 percent of the individuals (14 of 24) show clear evidence of cervical osteophytosis. Osteoarthritis shows the reverse regional distribution with the lumbar vertebrae most affected and the cervical vertebrae least affected.

The general correlation of osteophytosis and osteoarthritis with age is expected since both develop as part of the natural aging process. However, they are also multifactorial conditions that can be affected by genetics, metabolism, and nutrition (Wilczak and Kennedy 1998). Mechanical stress can also accelerate the age at onset as well as the severity of degenerative changes. The presence of moderate to severe osteophytosis and osteoarthritis in the youngest age group suggests causative factors in addition to normal age degenerative changes. The high frequency of cervical osteophytosis compared to that in the lower back, is also compelling evidence for the impact of strenuous labor on the vertebral column. Environmental factors such as nutrition are systemic, and while they may increase susceptibility to cartilage and joint breakdown, they would not be expected to affect the pattern of degeneration within the vertebral column. In relation to both age and mechanical

Figure 11.5: Severe osteophytosis of the cervical vertebrae in a male aged 35-45 years (Burial 63)

effects, osteophytosis generally affects the lumbar region first with the cervical about half as affected and the thoracic least (Bridges 1992; Jurmain 1999). The reversal of the normal pattern provides evidence for labor that resulted in mechanical strain to the neck. Further evidence is present in seven individuals with unambiguous pre- or peri-mortem fractures to the cervical vertebrae (Table 11.11). All but one also has modifications consistent with osteophytosis, osteoarthritis, or both in the cervical region.

The similar rates of cervical osteophytosis do not necessarily mean that males and females were performing the same types of labor, but only that both were subjected to repeated and severe stress of the neck. Diverse activities have been suggested as contributing factors to the development of cervical osteophytosis, including compression of the neck during milking, extension of the neck during fruit picking, and use of a tumpline for carrying loads on the back (Bridges 1994; Olin 1982; Wienkler and Wood 1988). Correlations between carrying loads on the head and cervical osteophytosis have also been suggested for Bronze Age Harappans (India) and prehistoric Native Americans from Alabama, as well as for contemporary grain porters from Zambia and South Africa (Bridges 1994; Levy 1968; Lovell 1994; Scher 1978). Loading of the shoulders as well as the head can place stress on the neck, particularly when the lower cervical and thoracic vertebrae are involved. In the ABG sample, four individuals have moderate to severe cervical and thoracic osteophytosis without involvement of the lumbar vertebrae: one female 25-34 years, one male 15-24 years, and two males of 50+ years old.

Sixty percent of individuals with cervical osteophytosis also had at least moderate cervical osteoarthritis. Theoretically, stress on the disks and vertebral bodies is primarily due to compression, while the apophyseal joints are stressed with rotation and bending. Many activities will result in both compression and bending stresses; for example, when carrying objects on the head the weight of the load may shift during walking causing lateral stresses in the head and neck. However, a substantial portion of individuals had osteophytosis without osteoarthritis, reflecting perhaps the diversity of the individual activities within the population, differences in anatomy, genetic predispositions, nutritional stresses, or disease. Certainly, the distribution of stress across the vertebral segments will vary among individuals and may influence the onset and progression of degenerative joint disease.

Unlike osteophytosis, the distribution of osteoarthritis in previous studies does not present as clear a pattern of regional distribution among the three vertebral segments. There is some bias toward lumbar involvement, but it is not uncommon for peak values to occur in either the thoracic or lumbar segments (Bridges 1994; Derevenski 2000). Biomechanically, this is not surprising since the apophyseal facets have less of a weight-bearing role than the vertebral bodies and disks. High levels of osteoarthritis in this sample suggest participation in labor involving bending and rotation of the spine or indirect stress to the back through limb muscles that directly attach to vertebrae. This is particularly true for the lumbar region where the early age for onset for severe osteoarthritis is striking. Stress in the lower back occurs during many general types of arduous physical labor including carrying, bending and lifting, as well as dragging heavy objects.

Schmorl's nodes

Schmorl's nodes are shallow, depressed pits occurring on the superior and/or inferior endplate of the vertebral bodies resulting from the pressure of cartilaginous protrusions of damaged intervertebral discs. (Figure 11.6)

The general pattern of spinal distribution for 22 affected males and 11 affected females (Table 11.4) is similar with the greatest occurrence in the lumbar region and the lowest occurrence in the cervical region for both sexes. Lumbar frequencies are equal, but male frequencies are more than double those of females in the thoracic vertebrae and triple those of females in the cervical vertebrae. Two females and six males have Schmorl's nodes in multiple vertebral regions.

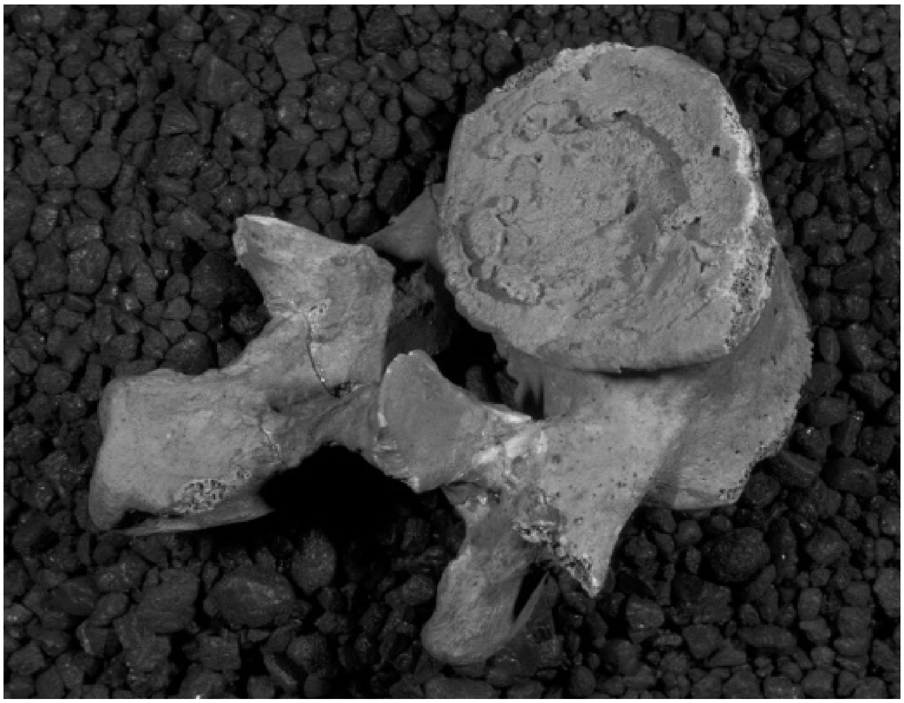

Figure 11.6: Schmorl's node depression of a lumbar vertebra in a male aged 35-45 years (Burial 70)

Table 11.4: Regional Distribution of Schmorl's nodes

	Males		**Females**	
	Number[1]	**Percent**	**Number[1]**	**Percent**
Cervical	6 (60)	10.0	1 (47)	2.1
Thoracic	10 (51)	19.6	4 (40)	10.0
Lumbar	14 (67)	20.9	9 (43)	20.9

[1]numbers in parentheses are sample sizes (n)

Age-related degenerative change is often considered the primary reason for Schmorl's node development (Aufderheide and Rodriguez-Martin 1998), but mechanical stress may be a contributing factor as appears to be the case in this population. The relative rarity of this condition in younger persons suggests that it only occurs earlier in life under conditions of extreme physical stress (Capasso et al. 1999). In the combined male and female sample, the most frequent occurrence of Schmorl's nodes is in the age range of 25-34 for all three vertebral regions (Table 11.5). The frequencies are over two times those found in the oldest sample of 50 years or greater. As with vertebral osteoarthritis and osteophytosis, the presence of Schmorl's nodes in younger individuals suggests factors other than age-related disc degeneration. While one might expect to see increase in the incidence with age when mechanical stresses are a factor, the higher frequency in younger individuals may simply reflect sampling bias in the labor history or genetic susceptibility (in conjunction with stress) of the individuals within each age group. Percentages of individuals with Schmorl's nodes in the cervical, thoracic and lumbar regions also affected with osteophytes in the same vertebral region are 28.6 percent, 42.9 percent and 21.7 percent respectively.

Table 11.5: Percentage of Individuals with Schmorl's nodes by Age[1]

Age	Cervical	Thoracic	Lumbar
15-24	0 (0)	16.7 (2)	15.0 (3)
25-34	12.5 (3)	31.6 (6)	36.4 (8)
35-49	7.5 (3)	8.6 (3)	22.7 (10)
50+	4.2 (1)	14.3 (3)	13.0 (3)

[1]numbers in parentheses are number of individuals with Schmorl's nodes

Spondylolysis

Unilateral or bilateral fracture of a vertebral neural arch and subsequent separation from the vertebral body constitute the defect of spondylolysis (Figure 11.7). Although technically considered a type of fracture, it is discussed here because it can be due to fatigue fracturing when presenting as typical spondyloslysis. Typical spondylolysis is a fracture in the lumbosacral region through pars interarticularis with L4 and L5 most frequently affected (Merbs 1996). The etiology of typical spondylolysis suggests both genetic factors, likely related to differences in vertebral morphology, and mechanical stress affecting the lower back such as general heavy labor and in athletics that stress the lower back such as football, gymnastics, and rowing (Merbs 1996, 1989).

Figure 11.7: Vertebral spondylolysis in a female aged 35-40 years (Burial 107)

Complete, bilateral spondylolysis of L4 or L5 was present in four adults from the ABG (Table 11.6). All of the individuals with spondylolysis also have at least one other pathological change of the vertebrae both within and outside of the lumbar region, including Schmorl's nodes and osteophytosis in three of the four burials. All four individuals show evidence of osteoarthritis of the lumbar apophyseal joints. Osteoarthritis is also present in the cervicals of Burial 37, in the thoraces of Burial 107, and in both the cervical and thoraces of Burial 11.

Table 11.6: Spondylolysis and Associated Vertebral Degenerative Changes

Typical Spondylolysis			**Other Degenerative Changes**[1]		
Sex	**Burial**	Age (yrs)	OP	OA	Schmorl's
Male	11	35-49	C, T, L	C, L	
Male	97	35-49		L	T
Female	107	35-49	T, L	T, L	T
Male	37	50+	C, T	T, L	T, L

[1]C = cervical, T = thoracic, L = lumbar

Examination of musculoskeletal stress markers (MSMs) and axial osteoarthritis reveals further evidence that the individuals affected by spondylolysis experienced heavy stress. Details of osteoarthritis and MSM scoring procedures are given in the respective sections of this chapter. Burial 11 is a male aged 35-50 who shows hypertrophy or stress lesions at 37 percent of 33 muscle or ligament attachments. These attachments include several associated with carrying or heavy lifting such as the triceps, biceps, deltoid, quadriceps, linea aspera, obturator exturnus/internus, and gluteus minimus/medius attachments. Moderate osteoarthritis of the hip and elbow are also present in the form of peripheral lipping of all articular surfaces. In the elbow, lipping is particularly prominent on the ulna suggesting bending stress as a greater factor than rotational stress.

Burial 97 is a male aged 35 to 50 years with extensive musculoskeletal stress markers (MSMs) that were scored as moderate to severe for 17 of 30 or 56 percent of the attachments examined, which is over twice the average percentage (25.2 %) of MSMs for all adult males. Moderate to severe osteoarthritic lipping is also present at the hip, elbow, wrist, and hand. The knee, ankle, and foot were not sufficiently preserved for scoring. The only female (Burial 107) with typical spondylolysis was aged 35 to 50 years. Thirty-nine percent of the attachments examined were scored as MSMs as compared to the average of 17.6 percent for all females. Some of the same patterns emerge as seen in Burial 11 with stress lesions at the brachialis, deltoid, linea aspera, quadriceps, and obturator internus/externus attachments. While mild lipping is present at most joints or joint complexes, only the knee was scored with moderate to severe lipping.

Burial 37 is a male aged 50+ years. In addition to the extensive changes in the vertebral column as detailed in Table 11.6, twenty-one percent of the attachments show significant hypertrophy or stress lesions including those of the brachialis, supinator, quadriceps and linea aspera. All of the joints examined in this older individual show at least mild osteophytic lipping, but more pronounced lipping occurs in the hip, ankle, knee, and foot. While all four burials show some correspondence between spondylolysis and other stress markers, there are also differences among the individuals. High levels of mechanical stress are indicated by MSMs for Burial 11, by osteoarthritis in Burial 37, and by both MSMs and osteoarthritis in burial #s 11 and 97.

Variability in the types of vertebral changes as well as in the degree and patterning of the associated MSMs and axial osteoarthritis, suggests a corresponding variability in the types of labor performed by this urban population. However, individual differences in genetics, nutritional levels and bone density, anatomy, and posture in the performance of similar task are also contributing factors to diverse manifestations of stress in the spine. Susceptibility to spondylolysis in particular has been correlated with anatomical variation in the lower back and preferred posture during the performance of strenuous tasks (Capasso et al. 1999). Merbs (1983) and Stewart (1953) both suggested holding the legs extended when sitting (as in a kayak) or when standing and working with materials on the ground contributed to the high incidence of spondylolysis among Alaskan natives. Even what appear to be very similar sorts of activities may show different skeletal manifestations upon closer examination. Grain porters in Zambia had fractures, herniations and other injuries most commonly in cervical vertebrae C_1 to C_4 while grain porters in Cape Province only showed injuries below C_4 (Capasso et al. 1999). So while there is evidence of general levels of high mechanical stress for the four burials examined here, one must be careful not to over-interpret the specific manifestations for any one individual.

Results of Appendicular Joint Analysis

In the upper limb, 22 females and 43 males have osteoarthritis in at least one of the joints or joint complexes, which included the shoulder, wrist, elbow and hand. For individuals with osteoarthritis and all four joint regions scorable, the average number of joints affected is 2.26 for females and 2.09 for males. If the joint and joint complexes are ranked by relative frequency of osteoarthritis, differences between the sexes are present (Table 11.7). Females have the highest incidences in the wrist for the 25-49 year age range, while males are highest in the elbow (Figures 11.8 and 11.9). The shoulder is least affected in both sexes. The greatest frequency difference between males (32.6 %) and females (19.4 %) is in the elbow.

In the lower limb, 40 females and 58 males have osteoarthritis in at least one joint or joint complex, which included the hip, knee, ankle, and foot. For individuals with osteoarthritis and all four regions scorable, the average number of joints affected is 2.39 per individual for females and 2.17 per individual for males. When the eight joint or joint complexes of the upper and lower limb are considered together, the average number affected in those with osteoarthritis is 4.11 for females (n = 26) and 3.59 for males (n =44). There were six individuals with all eight regions affected. Four of these were males of 50+, and two were females aged 25-34 years.

Table 11.7: Distribution of moderate to severe osteoarthritis in the upper limb

	Males		Females	
Age in yrs	**# affected[1]**	**%**	**# affected**	**%**
	Shoulder			
25-49	6 (46)	13.0	4 (31)	12.9
15-50+	15 (76)	19.7	12 (55)	21.8
	Elbow			
25-49	16 (49)	32.6	6 (31)	19.4
25-50+	29 (82)	35.4	14 (58)	24.1
	Wrist			
25-49	10 (38)	26.3	5 (21)	23.8
15-50+	18 (66)	27.3	10 (40)	25.0
	Hand			
25-49	8 (48)	16.7	5 (29)	17.4
50+	19 (80)	23.8	12 (55)	21.8

[1]Numbers in parentheses are sample sizes (n)

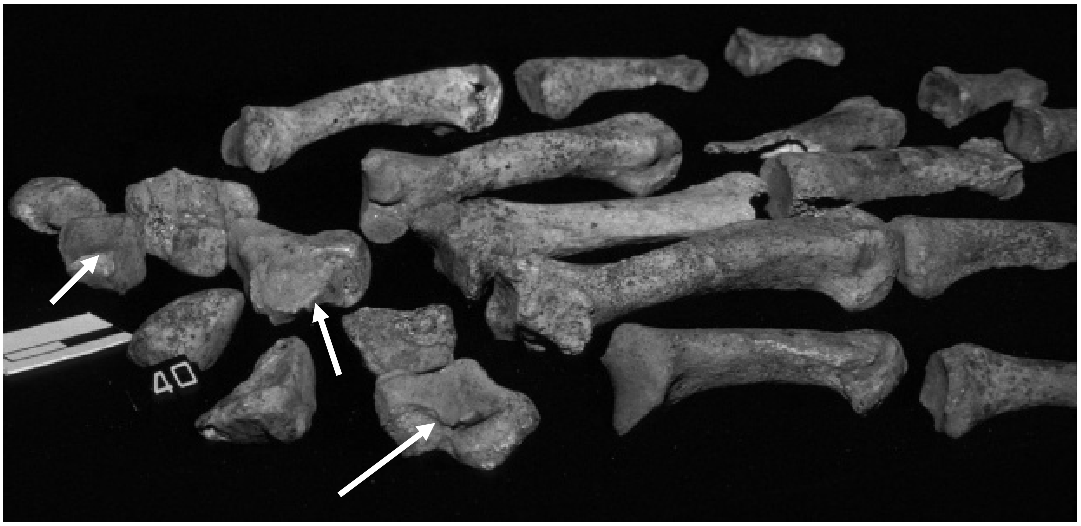

Figure 11.8: Osteoarthritis with marginal lipping in the wrist of a female aged 50-60 years (Burial 40).

Figure 11.9: Mild to moderate osteoarthritis in the humeral articular surface of the elbow in a male aged 30 - 40. A. anterior view, B. posterior view (Burial 11)

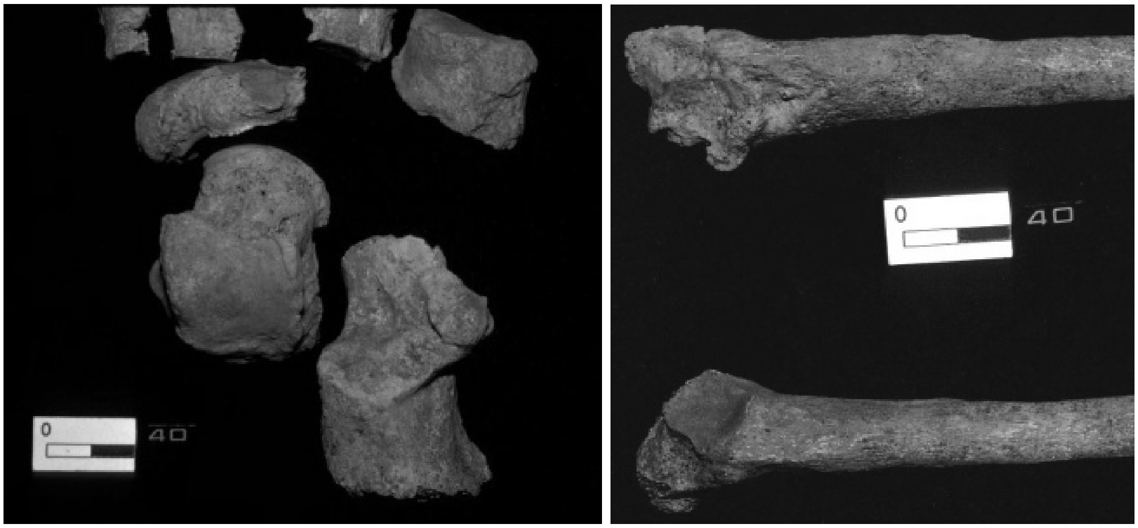

Figure 11.10: Osteoarthritis of the ankle in a female aged 50-60 A. superior aspect of the distal ankle articulations B. the proximal ankle articulation on the fibula (Burial 40)

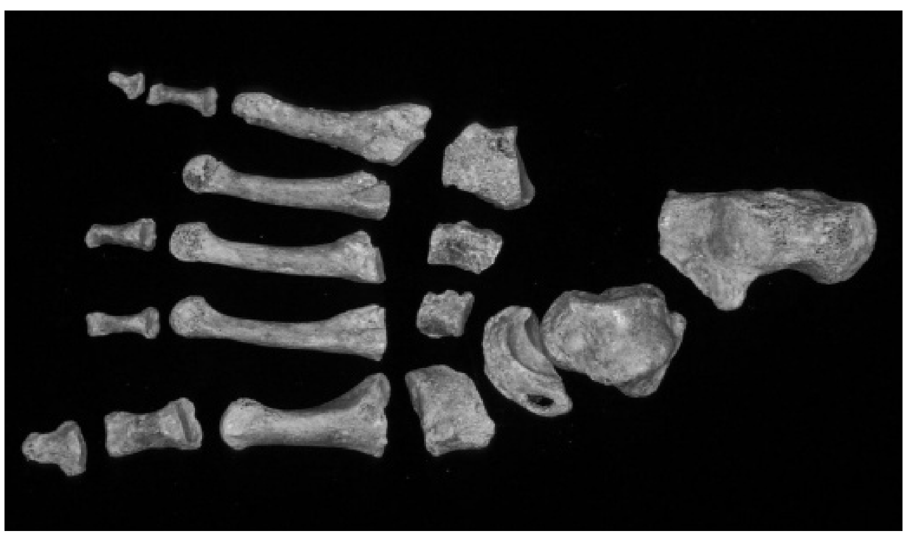

Figure 11.11: Osteoarthrits in the ankle and foot of a male aged 40-50 years (Burial 238)

There is a higher frequency of osteoarthritis in the lower limb than in the upper limb for both sexes (Table 11.8). Only the male elbow, and perhaps wrist, has comparable incidence levels. Both males and females have the highest lower limb incidence of osteoarthritis in the ankle (Figure 11.10). In females this is followed by the hip and by the knee in males. The ankle joint shows the greatest sex difference with 51.7 percent of females and 42.2 percent of males affected for the age range of 25-49 years, but this difference is not statistically significant.

Table 11.8: Distribution of moderate to severe osteoarthritis in the lower limb[1]

	Males		**Females**	
Age in Yrs	**# affected**	**%**	**# affected**	**%**
	Hip			
25-49	19 (51)	37.3	13 (31)	41.9
15-50+	33 (82)	40.2	22 (57)	38.6
	Knee			
25-49	14 (49)	38.6	13 (33)	39.4
25-50+	27 (82)	32.9	24 (62)	38.7
	Ankle			
25-49	19 (45)	42.2	15 (29)	51.7
15-50+	39 (75)	52.0	27 (56)	48.2
	Foot			
25-49	15 (45)	33.3	11 (31)	35.5
50+	28 (76)	36.8	20 (56)	35.7

[1]Numbers in parentheses are sample sizes (n)

It is difficult to examine age effects independently for males and females because sample sizes are as low as ten individuals when the sexes are considered separately by age. Since the joints or joint complexes do not show statistically significant sex differences, all are plotted as combined samples of males, females and unknown sex initially (Figures 11.12 and 11.13). The elbow is also plotted separately for males and females since the greatest sex differences were found at this joint

(Figure 11.14). Total sample sizes for the combined appendicular joints by age categories range from 17 to 54 individuals. The general trend for both upper limb and lower limb joints is toward increased frequencies of affected individuals with age. Nonetheless, a fairly large proportion of the youngest age group have moderate to severe degenerative changes. This is most apparent in the lower limb where incidences range from 15 percent in the foot to 25.0 percent in the ankle for 15-24 year olds. In the upper limb, the elbow of the youngest age group has the highest incidence of 21.7 percent. The lower limb is clearly more affected than the upper limb, and it is unlikely that incidences in the lower limb are simply a phenomenon of normal weight-bearing and age since moderate to severe osteoarthritis reaches quite high levels in the young adults and is pronounced in those aged 25-49 years as well. The graph also shows the trend for higher incidences in the ankle, with the greatest differences when compared to the hip, knee and foot in the 25-34 year age group. In the oldest individuals (50+), the incidence for all lower limb joints and joint complexes converge with those of the ankle at rates greater than 58 percent.

Sample sizes for osteoarthritis of the elbow range from nine for females aged 15-24 and 50+ to 36 for males aged 35-49 years. The trend for males to exceed females is interrupted in the age range of 25 to 34. In this group of 13 males, none showed significant osteoarthritis. The largest difference is in the 35-49 year age range where the male incidence was 44.4 percent (n=36) and the female was 18.8 percent (n = 16).

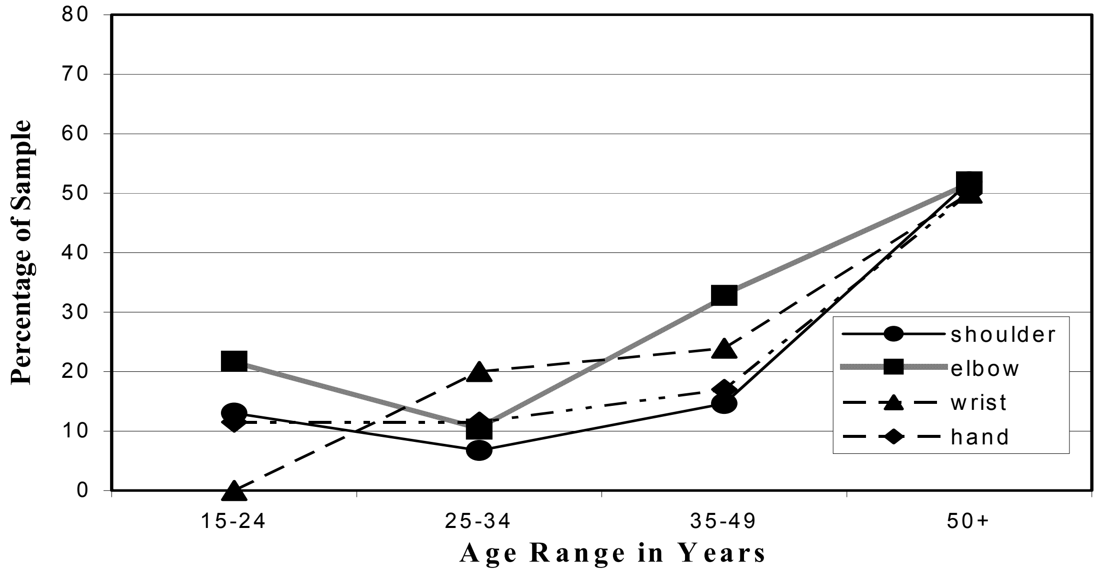

Figure 11.12: Age and incidence of moderate to severe osteoarthritis in the upper limb

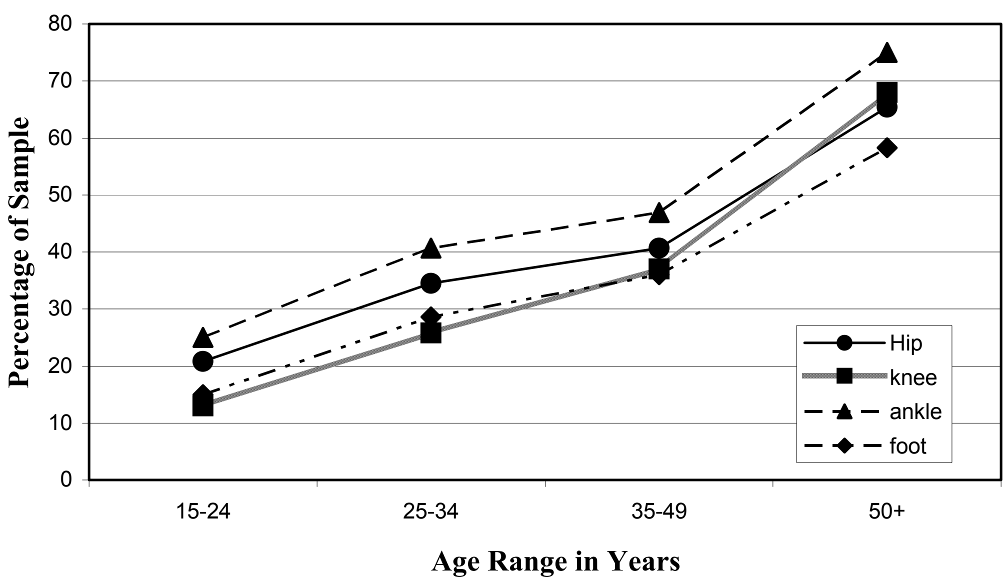

Figure 11.13: Age and incidence of moderate to severe osteoarthritis in the lower limb.

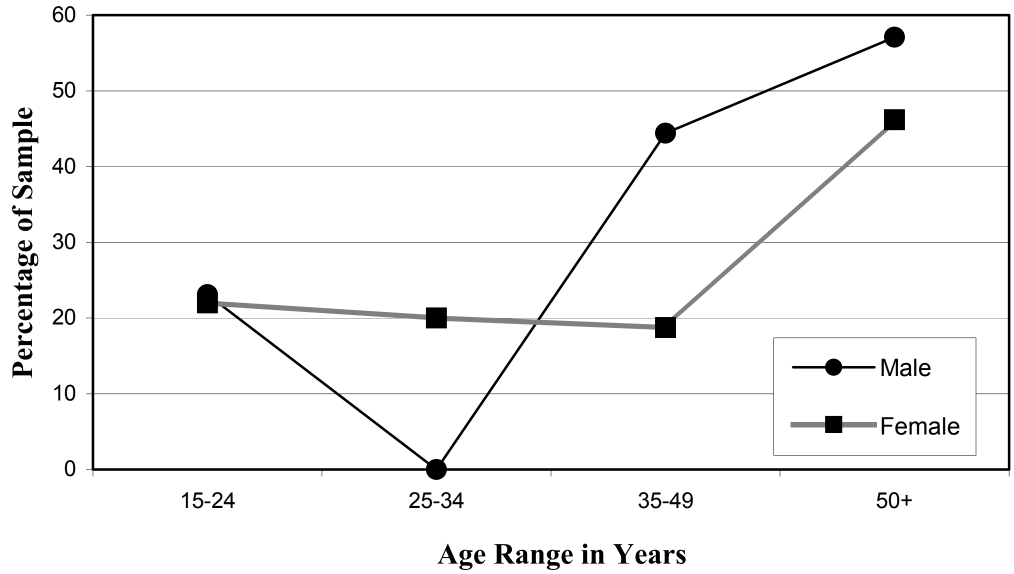

Figure 11.14: Age and incidence of moderate to severe osteoarthritis of the elbow

Incidence of osteoarthritis was higher in the lower limb, suggesting greater stress than in the upper limb. Activities that might be applicable in this population include walking over uneven surfaces, performing activities while squatting, and climbing stairs and ladders. It is not possible to say for certain which of these activities would be most important for this population, and it is likely that different stresses are factors for different individuals. An alternative explanation is that high general stress experienced in this population contributed to osteoarthritis development in both limbs, but rates in the lower limb are highest because of the additional weight-bearing burden. Perhaps this is true, but the pattern in the vertebral column is suggestive of the higher burden in the pelvic girdle. The higher incidence of osteoarthritis in the lower limb is compatible with the high levels of osteoarthritis of the lumbar vertebrae, supporting a difference in the activity loads of the upper and lower limbs. It is of interest that the highest incidence of osteoarthritis was found in the ankle since it is rare in the archaeological record as well as today (Rogers 2000). When it does occur, it is normally due to traumatic injury or other pathology. Certainly, abrupt trauma cannot be ruled out here.

For the elbow, there is no way to know if males aged 35-49 years with high osteoarthritis rates or males aged 25-34 with lower rates are more representative of the population. Therefore, it would be an over-interpretation to conclude that all males experienced more stress than females at the elbow. This example clearly illustrates the difficulties in making specific statements rather then discussing broad trends in this population where individuals performed a wide variety of tasks. All that can be concluded is that at least some individual males were likely to experience high stress levels at the elbow. This stress level could be due to habitual labor in this age group or traumatic injury, leading to the degenerative changes.

Musculoskeletal Stress Markers

Musculoskeletal Stress Markers (MSM) are distinct marks at the site of ligament and tendon attachments to the periosteum and bone. The types of bony changes include hypertrophic bone development that causes enlargement and the formation of distinct ridges and crests at the attachment, resulting in a rugose appearance. With extreme stress at the attachment non-lytic furrows or pits may develop, resulting in a stress lesion called an enthesopathy at a tendinous attachment or a syndesmoses at a ligament attachment. Both of these terms have been used to describe either hypertrophy and stress lesion or stress lesions exclusively. To avoid confusion, we will follow the terminology of Hawkey and Merbs (1995), referring to the more extreme furrow or pit development as stress lesions for both enthesial and syndesmosial sites.

Scoring of MSMs

Three attachments were scored in the head and neck, nineteen in the upper limb, and eleven in the lower limb. If hypertrophy or stress lesions were manifest at both the origin and insertion of a specific muscle or ligament the highest score was used. For most of the attachments, the greatest percentage of MSM expression was at the insertion where tensile stresses are most intense. For example, there were seven MSMs scored for the humeral origin of the brachialis muscle and 81 at its insertion on the ulna. Multiple muscles were scored together when they share a common attachment or when the attachments are located too closely for clear discrimination. Therefore, when referring to an attachment site in the singular, it may include several sites such as origin and attachment and/or multiple muscles. MSMs were scored as mild hypertrophy = 1, moderate/severe hypertrophy = 2, mild stress lesion =3, or moderate/severe stress lesion = 4 (Figures 11.15 and 11.16). In analyses of MSM frequency, only scores of two or greater are considered. Exclusion of mild hypertrophy ensures that only clear cases of MSMs are scored.

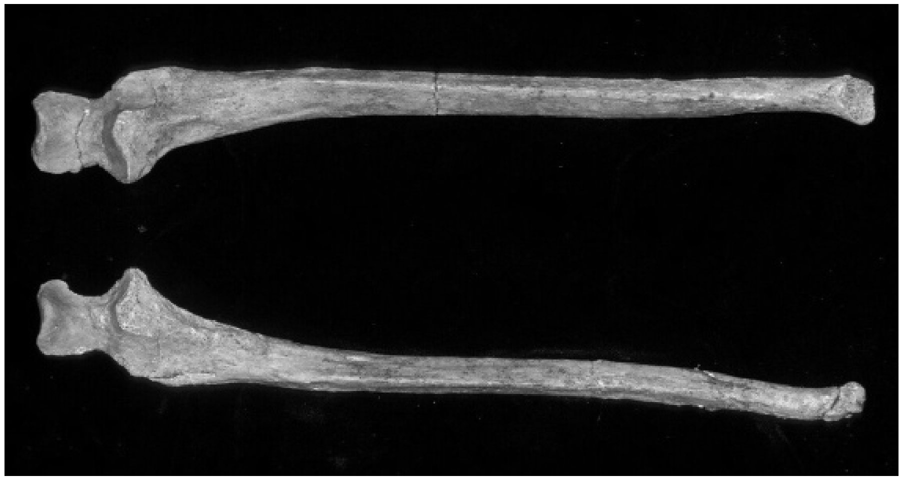

Figure 11.15: Severe Hypertrophy of the Ulnar Supinator Insertions in a male aged 40 - 50 Years (Burial 369)

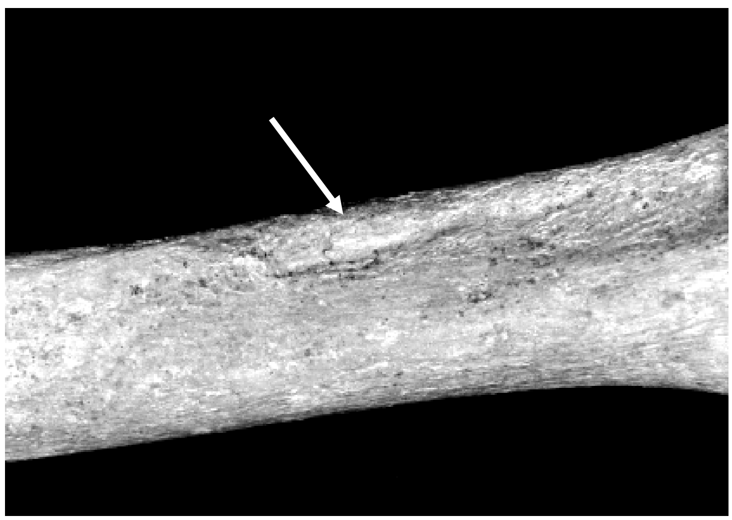

Figure 11.16: Stress Lesion of the Right Humerus in a male aged 20 - 23 years (Burial 181)

Results of MSM Analysis: Percentages of moderate to severe MSMs scored per individual were calculated based on the available number of attachment sites present. For these calculations, only individuals with at least nine scorable sites for the 33 attachments (>25 percent) are included. The average percentage of MSMs per individual is 25.1 for males and 19.6 for females (Table 11.9). This difference is significant (t-test, $p = 0.03$).

Average percent MSM scores do increase with age for both males and females. Although lower than other age groups, at least some attachments show significant hypertrophy and/or stress lesion even for individuals aged 15-24 years. The difference of 4.8 percent in average MSM scores in females between the two middle age groups are the lowest and correspond to an average of 1.6 insertions per individual (out of the 33 total). The youngest females show a difference of 6.5 percent when compared to females aged 25-34 corresponding to 2.1 few insertions per individual. For males, the difference between the two middle age ranges (7.6 percent or 2.5 insertions) is greater than the difference between 15-24 years and 25-34 year olds (4.1 percent or 1.4 insertions). These results are consistent with a previous study showing smaller average insertion areas for younger males for a sample of twentieth century African Americans and European Americans (Wilczak 1998).

These data suggest that accumulated stresses over time are usually necessary for MSM development, but those attachments under the greatest strain may develop quite rapidly. Alternatively or in conjunction with high stress and rapid development, it may indicate full integration at a very young age for males into the “adult” enslaved labor force, giving amply time for hypertrophy and stress lesion formation. Burial 323 is a male aged 15-24 who has moderate/severe MSM development at 39.4 percent (13 of 33) of his scorable attachments. Ten of these are stress lesions that include the linea aspera, quadriceps, biceps, deltoids and pectoralis/latissimus dorsi attachments. The large percentage of stress lesions suggests hard labor did begin at an early age for this individual.

Table 11.9: Average moderate to severe musculoskeletal stress marker scores by age[1]

Age (yrs)	n	Average # of attachments	Average % MSM	Highest % MSM
Males				
15-24	14	27.5	16.7	39.4
25-34	15	24.6	20.8	38.7
35-49	40	28.0	28.4	57.6
50+	15	28.2	31.4	60.6
All ages	92	26.6	25.1	60.6
Females				
15-24	11	27.7	10.1	27.3
25-34	17	28.0	16.6	39.4
35-49	20	28.3	21.4	41.9
50+	13	29.1	31.5	63.6
All ages[2]	68	24.9	19.6	63.6

[1]All results are for individuals with nine or more insertions present
[2]All ages includes adults with age indeterminate

Moderate to severe forms of MSMs are present in substantial frequencies. On a per case basis, females have an average of 6.5 occurrences and males 8.3 occurrences for the 33 attachments in the analysis. Since males have higher frequencies of MSMs and the age composition of the two samples varies, comparisons of specific attachments are presented by relative rank (Table 9.10). Of the ten most frequent MSMs, only two are not common to both males and females. The coracoclavicular ligament is ranked eighth in females (32.7 percent) and eleventh in males (28.2 percent). A much greater difference is seen for the biceps brachii muscle, which is ranked tenth for males (33.8 percent), but 23rd (8.2 percent) for females (Figure 11.17). In the lower limb the highest ranked attachments are the linea aspera and the gluteus maximus (1, 4 males and 2, 6 females; Figures 11.18 and 11.19). In the upper limb the deltoid, pectoralis major/latissimus dorsi, supinator, finger flexors, lateral scapula, and costoclavicular ligament were among the ten most common MSM for both males and females. Hypertrophy of the lateral border of the scapula may be another manifestation of teres major activity. It is also the origin of teres minor and the long head of the triceps, but MSMs of the insertions for these muscles are much less frequent in this population. Within the top ten, the rankings for the brachialis (Figure 11.20) is somewhat higher in females (1 vs. 5) while the Pectoralis major/Latissimus dorsi/teres minor is somewhat higher in males (3 vs. 7).

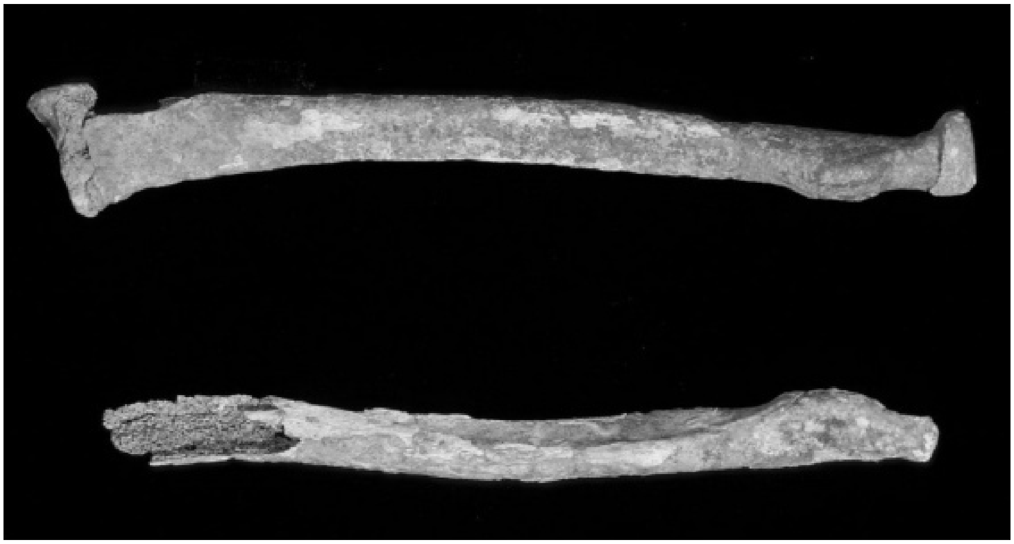

Figure 11.17: Hypertrophy of the biceps brachii insertion of the radii in a male aged 40 - 45 years (Burial 10)

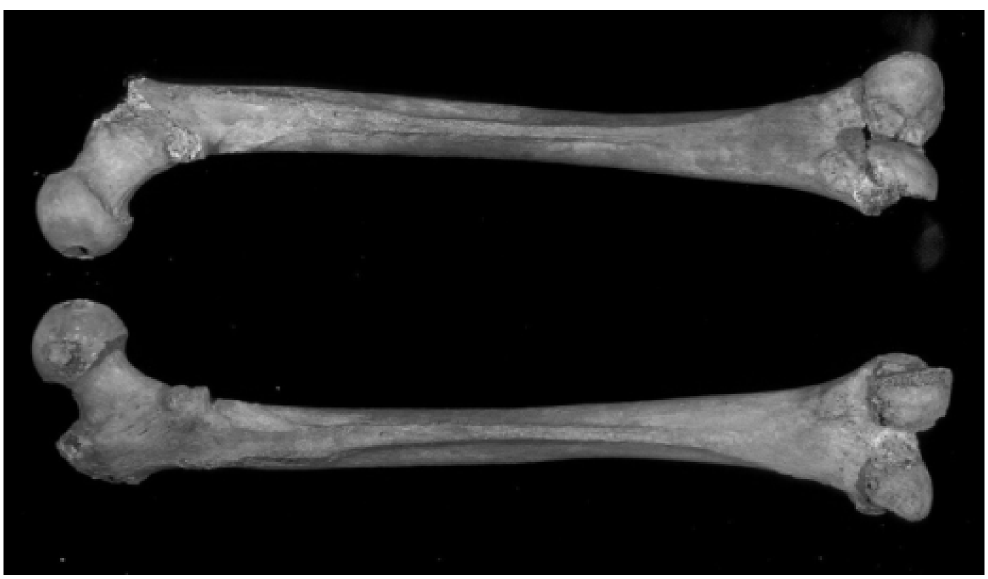

Figure 11.18: Hypertrophy of the linea asperae of the femora in a female aged 40 - 50 years (Burial 328)

Figure 11.19: Hypertrophy of the gluteus maximus insertions of the femora in a male aged 17 -18 years (Burial 174)

Figure 11.20: Hypertrophy of the brachialis insertions of the ulnae in a female aged 25-35 years (Burial 223)

Table 11.10: MSMs frequencies in males and females

	Male Attachment	#	%	Female Attachment	#	%
1	Linea aspera	58	66.7	Brachialis	32	55.2
2	Deltoid	51	62.2	Linea aspera	34	51.5
3	Pect. major, Lat. dorsi, teres major	48	59.3	Supinator	29	50.0
4	Gluteus maximus	49	58.1	Deltoid	30	48.4
5	Brachialis	45	54.9	Fingers flexors	27	44.3
6	Supinator	45	54.2	Gluteus maximus	29	43.9
7	Finger flexors	32	41.0	Pect. major, Lat. dorsi, teres major	25	42.4
8	Lateral Scapula	28	35.4	Coracoclavicular lig	18	32.7
9	Costoclavicular lig	25	35.2	Costoclavicular lig	15	27.3
10	Biceps brachii	26	33.8	Lateral Scapula	16	26.7
11	Coracoclavicular lig	20	28.2	Cranial base-occiput	13	25.5
12	Hamstrings	24	28.2	Quadriceps	13	18.3
13	med epicondyle-hum	22	26.5	Obturator in/ex	11	16.7
14	Cranial base-occiput	15	25.4	Finger extensors	10	16.4
15	Quadriceps	22	25.0	Hamstrings	10	15.8
16	Mastoid process	17	23.0	Rotator cuff	9	15.8

17	Lat epicondyle-Hum	19	22.4	Triceps brachii	9	14.8
18	Rotator cuff	17	20.7	Pronator teres/quad	8	14.3
19	Trapezius/nuchal	15	18.1	med epicondyle-hum	9	13.8
20	Iliopsoas	15	17.2	lat epicondyle-hum	7	10.8
21	Subclavius	12	16.9	Achilles tendon	7	10.4
22	Finger extensors	13	16.7	Gluteus medius/min	5	9.3
23	Triceps brachii	14	15.7	Biceps brachii	4	8.2
24	Obturator int/ext	13	15.1	Subclavius	4	7.3
25	Achilles tendon	12	13.6	Teres minor	4	7.0
26	Pronator teres/quad	7	8.6	Planterflexors	3	6.5
27	Gluteus medius/min	6	8.0	Iliopsoas	4	6.1
28	Dorsiflexors	3	4.2	Trapezius/nuchal	3	4.9
29	Plantarflexors	3	4.1	Dorsiflexors	2	4.5
30	Teres minor	3	3.7	Brachioradialis	2	3.6
31	Anconeus	2	2.4	Mastoid process	1	1.8
32	Brachioradialis	1	1.3	Intercondylar eminence	0	0
33	Intercondylar eminence	1	1.4	Anconeus	0	0

The cutoff point for further discussion of the ten most frequently affected attachments is arbitrary since there is no clear breakpoint between common and uncommon MSMs in this population. There is, however, some pattern in the data with several MSMs related to movement around the shoulder joint found in high frequencies in both males and females. Pectoralis major, latissimus dorsi and teres major insert into the intertubercular groove of the humerus. All three muscles act to adduct, extend and rotate the humerus, the first two medially and the teres major laterally. They are sometimes called "climbing muscles" because they pull the torso up when the arms are fixed. In addition, the pectoralis can assist in flexing the humerus to the horizontal position, at which point the deltoid is necessary through full elevation. Latissimus dorsi is a powerful retractor of the pectoral girdle during activities such as rowing and the down stroke in swimming. The MSMs in the deltoid, which can abduct, flex, extend, and laterally and medially rotate the humerus depending upon which fibers are active and the position of the arm, also suggest circumductory motions or loading of the shoulders and pushing loads up above shoulder height. Stress in the shoulder is also apparent for the costoclavicular ligament, which attaches the medial clavicle to the first rib and limits the clavicle's anterior and posterior movement. The corococlavicular ligament attaches the clavicle to the coracoid process and limits forward and backward movement of the scapula. This pattern of stress suggests activities including alternating flexion and extension of the arm toward the chest with the elbow bent as has been described in skin scraping among Inuits (Hawkey 1988; Hawkey and Merbs 1995), lifting heavy objects up from the ground, stacking and unstacking materials, and placing burdens upon the shoulders or head. Overall, the pattern in the shoulder is compatible with many types of general labor involving heavy lifting and carrying as might be expected for this population.

Hypertrophy of the brachialis, which flexes the elbow, supports the presence of repetitive types of back and forth motion of the arm and forearm. While higher in women, both sexes show evidence of stress at this attachment. An additional flexor of the elbow and shoulder, the biceps brachii, shows hypertrophy in men. This could relate to general carrying functions since the biceps brachii opposes extension of the forearm against a load carried with the elbows flexed and the forearms extended in front of the body or when carrying heavy buckets or baskets in the hands with the arms down at the sides of the body (Galera and Garralda 1993). High frequencies of this MSM have been reported in masons, bakers and agricultural populations. Biceps brachii also supinates the forearm and both males and females have stress lesions and hypertrophy of the supinator muscle attachments. Supination occurs during twisting of the forearm, the type of motion used when opening a jar. The biceps is only important in supinating the forearm when the elbow is bent and the supinator muscle acts alone when the elbow is straightened (Kelly and Angel 1987). Supination is required in many skilled crafts such as sewing and weaving that also use alternating extension and flexion of the elbow. These types of activities are of interest since males and female finger flexor MSMs are ranked seven and five respectively. Supinator MSMs have been ascribed to activities that manipulate loads while the elbow is extended for tasks including citrus fruit picking, paddling a boat or canoe, and using heavy tools with a long reach such as furnace irons (Capasso et al. 1999).

High stress in the lower limb at the linea aspera and gluteus maximus attachments also point to heavy labor. The gluteus maximus is an extensor and abductor of the thigh. Its function as an extensor is not important in ordinary walking, but rather in more powerful movements such as climbing, stepping on a stool and raising the trunk from a flexed posture. Muscles directly attached to the linea aspera are the adductors mangus, brevis and longus, and the short head of the biceps femoris. The edges of the origins for the quadriceps muscles, vastus lateralis and vastus medialis, extend to the lateral rim of the linea aspera and may be especially important in the development of the extreme hypertrophy and distinctive "mesa-like" shape seen in pilasterism. The adductors are important in maintaining balance during walking. Adductors mangus also can act to flex an extended thigh and longus can extend a flexed thigh. The short head of the biceps femoris acts to flex the knee. The vastus lateralis and medialis are two of the main extensors of the knee and are active in movements such as stair climbing and squatting. It is possible that they contribute to the MSMs seen in at least some individuals since the quadriceps insertion at the knee is affected in 25.0 percent of males (#15) and 18.3 percent of females (#12). Linea aspera development has been reported in a several groups with strenuous locomotor activities including Canadian fur traders who jogged up steep portage trails, sixteenth century sailors, and horseback riders (Capasso et al. 1999). The combination of linea aspera and gluteal MSMs suggests a greater role for hip/flexion extension stress rather than adduction stress. This new role is consistent with picking up heavy loads both by bending at the hip and lifting up the burden or, as previously suggested, when lifting from a squatting posture (Mack et al. 1995). However, there is a great range of activities that could produce the pattern seen here, so it is not possible to ascribe these changes to one specific habitual behavior.

The examples from previous studies given in conjunction with MSMs throughout this report are used to illustrate the range of activities suggested as a cause of the lesions seen and not to assign specific tasks to this population. While general load carrying would be expected as part of the labor for many enslaved, some of the same MSMs are most likely caused by different activities among these individuals. It is also important to remember that unlike the culturally distinct and more standardized labor pattern expected in an medieval agriculturalists or in a thirteenth century Inuit population, urban enslaved people would perform many types of labor. As we look at the population and the various MSMs with high frequencies, it must not be forgotten that those particular MSMs do not represent the remains of any one individual. The significance of the high levels of MSMs in the shoulder and femur is suggestive because it would be associated more with heavy forms of labor rather than skilled crafts. It is interesting that males and females show the same general pattern of stress but that there are some differences that may reflect sex differences in the types of work performed. Alternatively, they may reflect sex differences in anatomy and biomechanics.

Comparisons with other Enslaved Populations

There are few studies of enslaved skeletal populations in the Americas, and the type of information and number of individuals available vary considerably (Table 11.11). Poor preservation can also limit collectable data. This is the case for a Barbados, West Indies, enslaved plantation series, where analysis was largely confined to dental characteristics (Corruccini et al.1982). Thus the number of enslaved populations where MSMs have been studied is extremely limited with just four burial sites documented. In addition, the Kelly and Angel's (1987) plantation sample does not comprise a single cemetery sample but instead scattered burials from across Maryland and Virginia.

Direct comparisons of the incidence of specific markers are problematic due to differences in data collection methodologies across studies. However, it is at least possible to compare general patterns of the types of stresses experienced. Kelly and Angel (1987) give no precise descriptions relating to the occupational markers in the plantation/farm slave sample. They did find overall nutrition and longevity for Catoctin males were greater than for rural enslaved and attribute this to the value placed on skilled workers by the slave-holders, perhaps resulting in better nutrition and living conditions.

Markers of work-stress in the Catoctin industrial enslaved sample are interesting, given the association of these enslaved workers with the ironworks and the relatively well-defined labor pattern. This sample does show some broad similarities to the ABG particularly the early age of onset for MSMs: 1) an 18-20 year old female has well-developed attachments particularly for the deltoid tuberosities and the clavicular attachments, 2) the youngest adult male around 20 years old has marked supinator crest and gluteal development, 3) a male in his late twenties also showed marked arthritis of the knee and right elbow, and 4) a female of approximately 18 years has a Schmorl's node. In general, Kelly and Angel (1987) paint a picture of fairly heavy stress with evidence of heavy lifting inferred from the frequency of deltoid, pectoral, and teres major MSMs, as well as shoulder and vertebral breakdown. These general patterns are shared with the ABG sample. There are several cases of cervical “arthritis” (osteophytosis?) that they associate with skilled craft persons rather than carrying loads due to its co-occurrence with MSMs in the finger phalanges.

Table 11.11: Skeletal Studies of MSM in Enslaved African Americans

Location	Dates	n[1]	Population	Reference
Charleston, SC	1840-1870	28	plantation slaves	Rathbun (1987)
New Orleans, LA	1721-1810	13	urban slaves	Owsley, et al. (1987)
Catoctin, MD	1790-1820	16	industrial slaves (ironworker)	Kelly & Angel (1983, 1987)
MD and VA	1690-1860	76	plantation/farm slaves	Kelly & Angel (1987)

[1]includes adult remains only

In their earlier work (1983), Kelly and Angel also suggest a specific link between hypertrophy of the supinator crests in Catoctin males with “manipulating an iron with long reach.” A later paper, however, acknowledges a considerably broader explanation of precision crafts work and use of an axe.

Rathbun (1987) also documents physical stress within a rural enslaved population from South Carolina. Unfortunately, he provides no information on age occurrence of stress markers, but the presence of hip osteoarthritis in 100 percent of the male sample implies at least some individuals in their 20s were afflicted. As measured by rates of osteoarthritis, stress was most apparent in the shoulder, hip and lower vertebrae. This varies from the results of the ABG where appendicular osteoarthritis was lowest in the shoulder and moderate in the hip in comparison to the knee, ankle and foot. Of interest is the similarity when one examines incidence by sex. At both South Carolina and in our New York City sample, males were more frequently affected by osteoarthritis of the elbow and females at the knee. While the exact physical stresses and labor varied between these two populations, these similarities may be a signature of broad occupational differences with males lifting and carrying more and female stress at the knee associated with bending and kneeling in household labor tasks. Incidence of cervical osteophytosis was similar to lumbar rates in males at South Carolina, but female cervical rates were nearly twice that of the lumbar rates. This suggests greater sex differences in the regional stresses of the neck and back than is found at the ABG. Perhaps this signals greater differences in the types of carrying done by males and females in this rural population versus our urban sample or, as suggested at Catoctin, females bending the neck while performing some types of craft work and/or household work. The only MSM mentioned by Rathbun (1987) is the supinator crest insertion, which was more frequently affected in males than in females. Once again, no significant sex difference in this attachment was found for the ABG.

Owsely et al.'s (1987) sample from New Orleans should be most similar to the one from the ABG since it also consists of an urban rather than rural enslaved population, albeit with a very small sample size of thirteen individuals. It is unclear at what age degenerative joint changes are first observable in this population, but only one female showed moderate/severe lipping of the glenoid fossae while eight males showed pronounced osteoarthritic changes of various joints. In this study, joint surfaces were scored separately, so it is somewhat difficult to compare with our results. However, the upper limb in general is more often affected than the lower limb, a reversal of the pattern seen at the ABG. Greater similarities are found in MSMs for males with hypertrophy of the deltoid, supinator and biceps brachii insertions. Muscle attachment site changes in the lower limb are "equally profound" for most males. While females had lower overall MSM scores at the ABG, the sex differences in New Orleans seem much greater with only relatively minor hypertrophies in females, suggesting to the authors that they were performing less heavy physical labor than males, perhaps as house slaves. At least two of the older African American males at New Orleans did not show MSM development, again suggestive of variability in the severity of labor within urban enslaved populations and a social hierarchy even among enslaved. Consistent with this finding, the ABG population has incidences of osteoarthritis and MSMs that vary greatly among individuals independent of age. Both urban sites contrast with the more consistently high levels of stress documented in the rural enslaved of South Carolina who presumably would have engaged in plantation and farm work with less variability in the types of tasks performed.

Conclusions

There are no historic documents indicating the occupation or types of forced labor experienced by specific individuals from the ABG. Nor is it a site such as Catoctin Furnace or a hunting and gathering society where a limited number of activities might be inferred from contexts. In a series such as that from the ABG, linking individuals with specific occupations would be imprudent when one considers the wide range of possible activities that might affect a single marker, differences in individual anatomy, and idiosyncrasies in the way a single task may be performed (Capasso et al. 1999; Jurmain 1999; Knüsel 2000 Stirland 1991). The inability to confidently assign specific occupations to individuals does not imply that all analyses of habitual activity markers are meaningless. Information about the general labor conditions and levels of mechanical stress can be assessed. The most consistent results of this study are those that suggest strenuous labor began at an early age for at least some individuals, based on the presence of osteophytosis, osteoarthritis, enthesopathies, and Schmorl's nodes in the youngest age category of 15 to 24 years. Osteoarthritis in the lower limb and especially the ankles of individuals 15 to 35 years old suggests high general stress, perhaps walking on rough terrain, inclines or stairs with loads. Osteophytosis and osteoarthritis of the cervical vertebrae together with hypertrophy of the linea aspera, gluteus maximus and deltoids provides evidence of lifting and carrying loads on the back, shoulders, or head.

Few sex differences are present, so there is little evidence that males and females were specifically involved in activities that would result in large differences in overall mechanical stress levels. This does not mean that certain labors were not specifically designated to one sex, just that each sex could have performed separate but equally arduous tasks on a regular basis. While sex differences are not common, they do occur. The elbow joint shows somewhat higher frequencies of osteoarthritis among males along with relatively higher hypertrophy for the biceps brachii and pectoralis major/latissimus dorsi/teres minor attachment, all of which are associated with carrying and lifting loads. In females, there is a relatively higher ranking of hypertrophy of the coracoclavicular, supinator crest and brachialis, which are associated with repetitive back and forth motions and forearm supination (these other muscles are also included Pectoralis major/Latissimus dorsi/Teres minor). Variability among individuals in the number and severity of stress markers has been emphasized throughout this chapter. This result is consistent with the labor of both free and enslaved individuals in an eighteenth century urban environment.

Trauma

Dislocation: Only one clear case of a dislocation is apparent in the remains. It is in the left tempromandibular joint of a male aged 25-34 years (Burial #151). Dislocations do not often leave a skeletal signature and when they do, they are usually subtle (Jurmain 2001). It is likely that dislocations are under-diagnosed in all skeletal populations.

Fracture scoring: Premortem fractures were diagnosed when there was any remodeling of the bone (usually extensive healing), indicating survival after the trauma occurred. Perimortem fractures (unhealed fractures in living bone that occurred around the time of death) are those that are clearly not caused by recent burial/geologic processes, excavation or curation. Because it is often difficult to distinguish perimortem and postmortem fracture, a third category of ambiguous perimortem is included in the analysis.

Evidence of trauma in the skeleton is an indicator of both accidents associated with labor and violence against the individual. One would expect to observe fractures associated with both sources in an enslaved population. Perimortem fractures can be especially informative in the case of violence. While it is not usually possible to associate fractures with cause of death (Burial 25, below, representing such a case), perimortem fractures are almost certainly indicative of the manner of death.

Results of Fracture analysis: A total of 117 fractures in 23 males and 81 fractures in 18 females are present in adults (Tables 11.12). The cranium is the most common site for the fractures in males (23.5 %; Figure 11.21) followed by the ribs (11.4 %). Cranial fracture (11.1 %) is common relative to other elements in females and is similar to the percentage of fractures in the femur (12.4 %). The vast majority of these fractures are either perimortem or ambiguous perimortem for both males (79.5 %) and females (88.9 %). Equal numbers of fractures are found in the upper and lower limbs (Table 11.13). Premortem fractures in females are primarily in the hands and feet (5 of 9), but in males they are found in all regions except the skull.

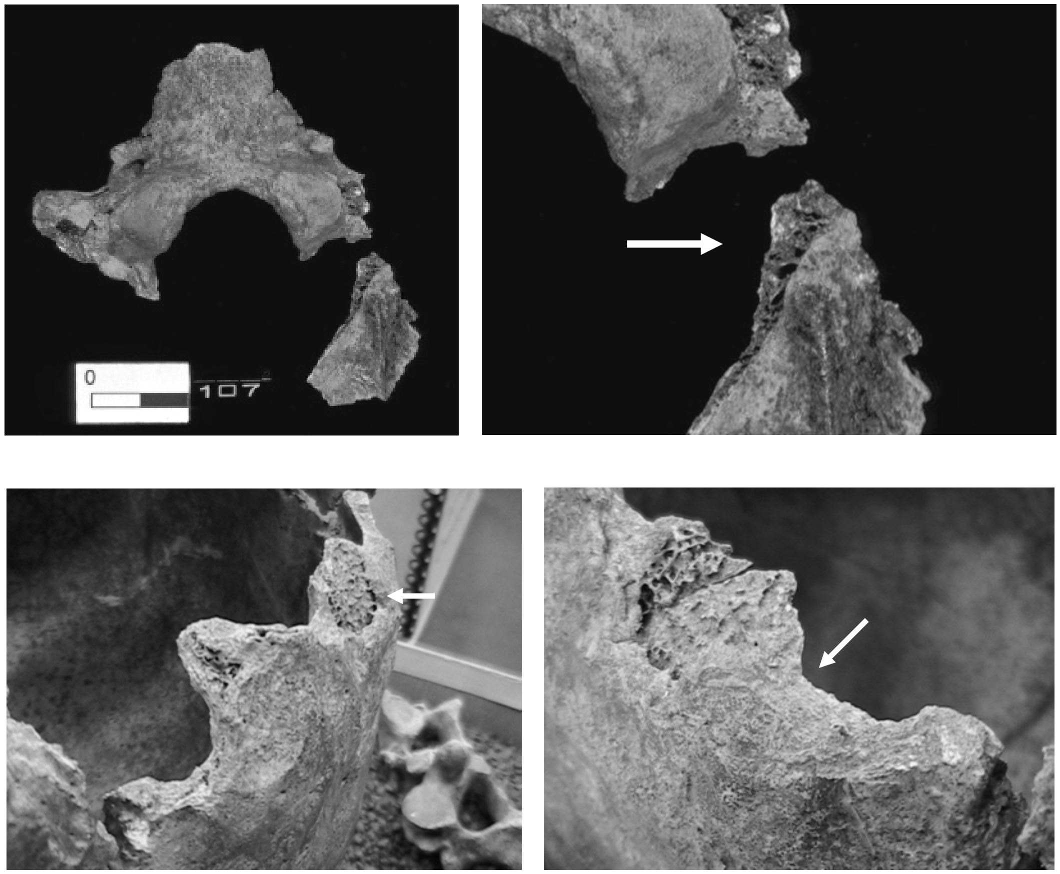

Figure 11.21: Ring fractures of the base of the skull in a female aged 35-40 years (Burial 107) The basilar is shown (top left) with a perimortem fracture (close up, top right). Other fractures are shown in the posterior occipital base (bottom left) exhibiting a beveled shape consistent with perimortem fractures (close up, bottom right). Ring fractures result from collision of the spine and skull base that can result from excessive, traumatic loading on top of the head (axial loading) (See Hill et al. 1995) or accidental or deliberate force to the top of the head such as diving on ones head or being thrust into a wall.

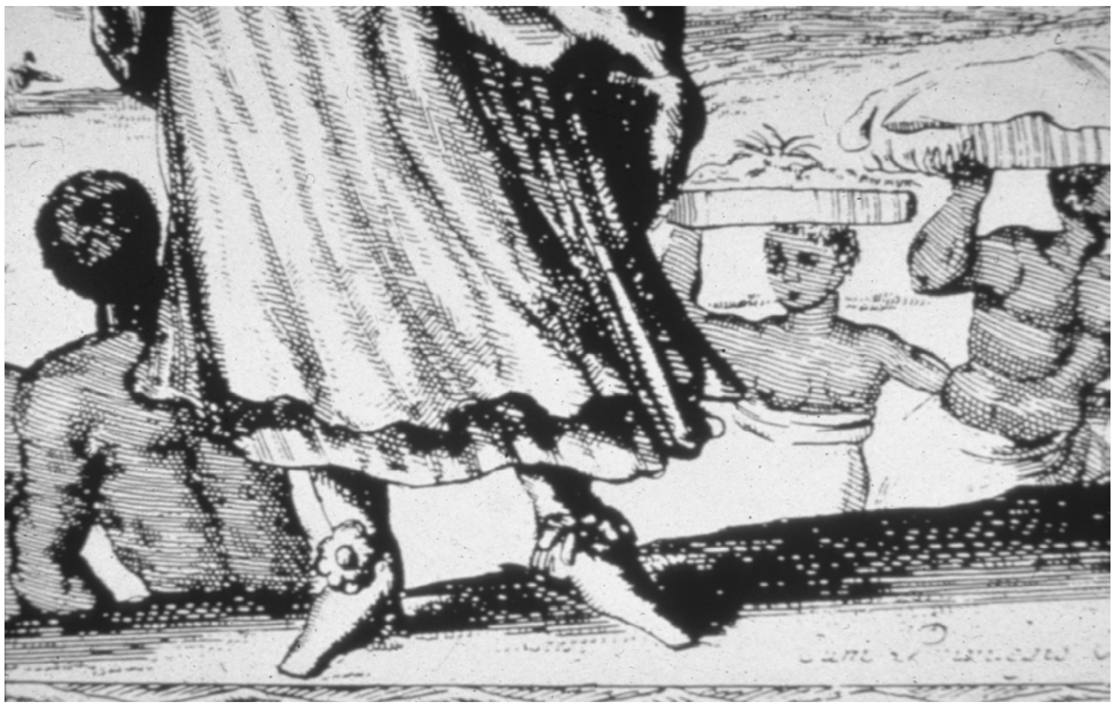

Figure 11.22: Seventeenth Century Drawing of Africans in New Amsterdam showing normal axial loading.

Table 11.12: Number of fractures by skeletal element in adults by sex[1]

	Males				Females			
	Pre[2]	Peri	Am	%	Pre	Peri	Am	%
Cranium		9	19	23.5		5	4	11.1
Mandible			1	0.9		1	1	2.5
Cervical vert	1	2		2.6	2	2	1	6.2
Thoracic vert	2	2		3.4		1	1	2.5
Lumbar vert		1	1	1.7		3	2	6.2
Rib	3	4	4	9.4	1	2	2	6.2
Clavicle	1	1	1	2.6		2		2.5
Scapula		4	1	4.3		5	2	8.6
Humerus		1	2	2.6		4	1	6.2
Radius	3	2	3	6.8		5		6.2
Ulna	3	1	4	6.8		6		7.4
Pelvis		8	2	8.6		5	1	7.4
Femur		4	6	8.6	1	8	1	12.4
Tibia	1	2	2	4.3		4		4.9
Fibula	4		3	6.0		3		3.7
Metacarpal			1	0.9	2			2.5
Hand phalanx			2	1.7				0
Metatarsal	1			0.9	1			1.2
Foot phalanx	5			4.3	2			2.5
Total	24	41	52		9	56	16	

[1]Pre = premortem, Peri = perimortem, Amb = ambiguous perimortem

[2]Vertebral fractures do not include spondylolysis (see Table 6)

Table 11.13: Number of fractures by skeletal region in adults by sex

	Males				Females			
	Pre[1]	Peri	Amb	%	Pre	Peri	Amb	%
Skull	0	9	20	24.8	0	6	5	13.6
Axial	6	9	5	17.1	3	8	6	21.0
Upper Limb	7	9	11	23.1	0	22	3	30.9
Lower Limb	5	14	13	27.4	1	20	2	28.4
Hands & feet	6	0	3	7.7	5	0	0	6.2

[1]Pre = premortem, Peri = perimortem, Amb = ambiguous perimortem

The distribution of fractures among the individuals is especially interesting. The average number of fractures among all individuals with fractures is 5.1 for males and 4.5 for females. If ambiguous perimortem fractures are excluded, the averages are 2.8 for males and 3.6 for females. Averages in this case are misleading as a few individuals account for the majority of fractures (Table 11.14).

A female aged 15-24 (Burial 205) has the greatest number of fractures and all 32 are perimortem. The fractures are distributed throughout the skeleton including the long bones of the arms and legs, the vertebrae, and the skull (Figure 11.23 and 11.24). Burial 89 is a female aged 50+ with 2 premortem fractures of the right hand and 8 perimortem fractures to the right side arms, legs and pelvis. She also has a fracture in the occipital and cervical vertebrae. Of the 23 fractures in a male aged 50+ one is a premortem fracture of the left clavicle. The perimortem fractures are distributed throughout the body in the long bones of limbs, the pelvis and vertebrae. He has no fractures in the skull. Burial 171 is a male with 4 premortem fractures of the left and right distal radius and ulnae. The perimortem fractures are located in the skull, vertebrae and ribs.

Table 11.14: Number of premortem and perimortem fractures per individual

# of fractures	# of Males	# of Females
1	5	9
2	4	2
3	3	
4		1
6		1
10		1
17	1	
23	1	
32		1

Subadult fractures: Fractures are present in three subadults aged 10-14 of unknown sex. Burial 253 has a premortem fracture of the occipital and left temporal (Figure 11.25). Burial 180 has two premortem fractures of the left clavicle. There are two ambiguous perimortem fractures to both the radii and ulnae. All of the 18 fractures in the child of Burial 180 are perimortem. They are distributed throughout the skeleton including the long bones of all four limbs, the pelvis and the cranium.

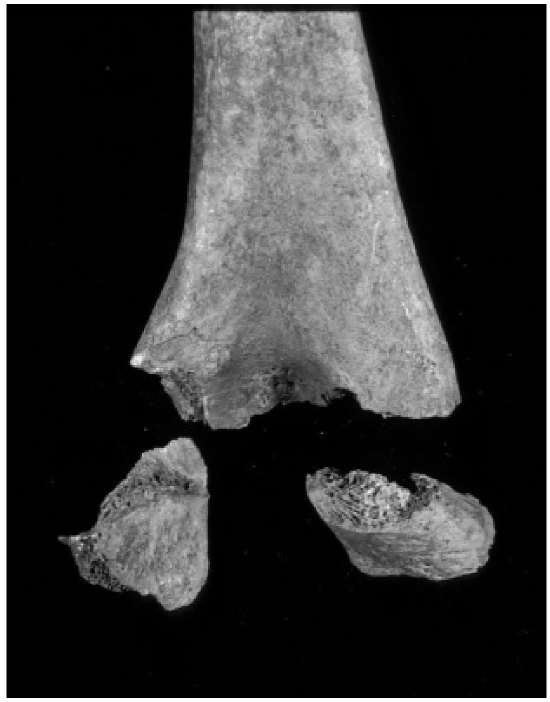

Figure 11.23: Perimortem fractures of the humerii in a female aged 18 - 20 years (Burial 205)

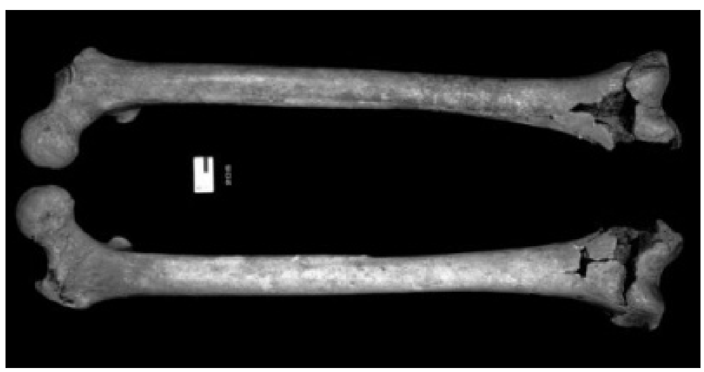

Figure 11.24: Perimortem fractures of the femora in a female aged 18 - 20 years (Burial 205)

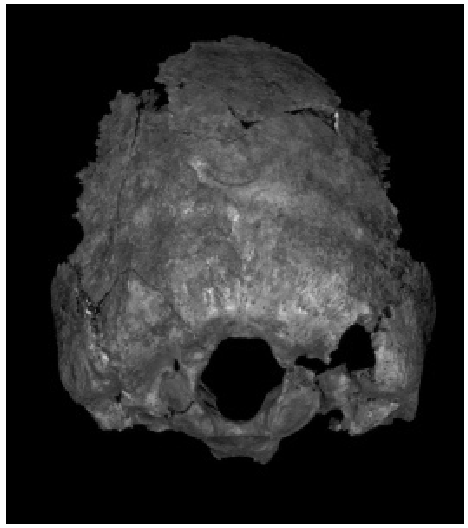

Figure 11.25: Premortem occipital fracture in a subadult aged 13 - 15 years (Burial 253)

Numerous individuals in this population have fractures, and it is especially telling that many of them are perimortem. It is certainly possible that at least some of these fractures are related to the cause of death, particularly in cases of perimortem cranial fractures. For individuals with extraordinarily large numbers of perimortem fractures, it is unlikely that they were the result of accidental injury. Captives were subject to being beaten and murdered. It is also possible that the fractures were inflicted shortly after death for unknown reasons.

Burial 25 is the most dramatic case of interpersonal violence in the **ABG** population. A 20-24 year old, 5'1" tall woman, Burial 25 had been found with a lead musket ball lodged in her ribcage (Figure 11.26). In her pathology assessment in the file of Burial 25, Osteologist M.C. Hill writes "smooth, gracile cranium and mandible; maxilla and mandible exhibit old, darkly stained fractures with beveled edges. The patterning of these fractures (restricted to the face) is consistent with a possible La Fort injury…" With regard to the lower arms, the left radius was shown to be shattered with some of its fractures showing darkly stained and beveled edges. The right radius "has a spiral green bone fracture of the distal metaphysis. There is a large flake of cortical bone missing from the anterior surface in the area of the fracture. Examination of the margins of the flake shows what appears to be a ridge of new bone along the margin and a "web" of new bone inside the flaked area. This area corresponds anatomically to the area of inflammatory periosteal activity on the right ulna." What is described here is a young woman who had been shot and who had also received blunt force trauma to the face (a rifle butt would customarily have been used to finish a shooting victim), a "spiral" or oblique fracture of the lower right arm just above the wrist (Figure 11.27) caused by simultaneous twisting and pulling. These fractures by virtue of their beveled form and dark color are consistent with the fracture of living bone and were definitely not caused by the excavation. The small trace of new bone and of adjacent inflammatory response suggests that this woman lived for some short period, no more than a few days, after she was beaten. Her left arm also shows evidence of perimortem trauma but with less certainty than her other fractures exhibit.

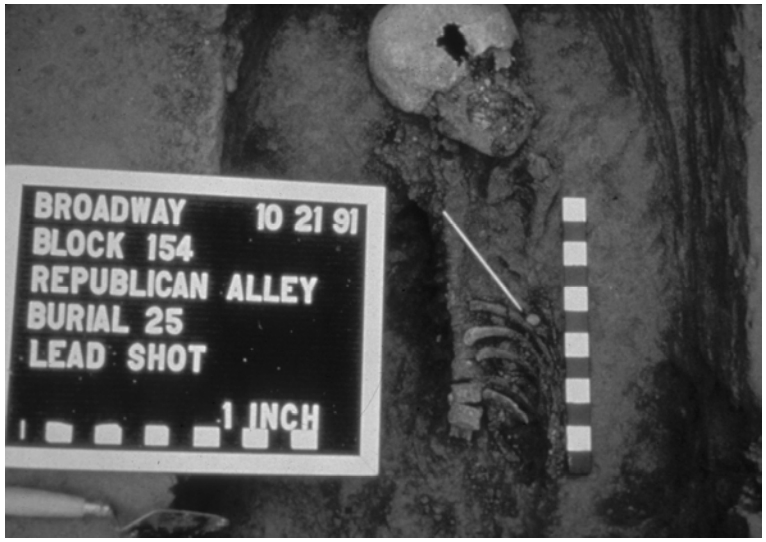

Figure 11.26: Burial 25 is shown in situ with musket ball.

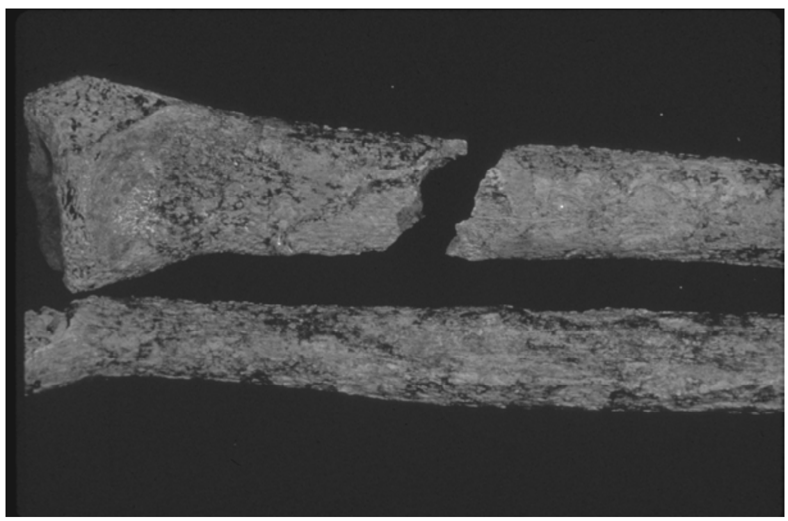

Figure 11.27: Spiral fracture in lower arm of Burial 25

The musket ball was located in the left chest. A large hole exists at the center of the shattered left scapula, suggesting that the projectile had entered through the upper left back. Old fracture surfaces of the ribs were also suggestive of the extent of damage due to the musket ball within the thorax of this young woman. The thinness of the scapula, however, makes an observation of beveling (expected when living or “green” bone breaks) difficult so that assessment of the point of entry remains plausible though inconclusive. Burial 25, according to Holl’s archaeological report (Holl 2001:116), is part of a “tight group of three burials that seems to constitute a well-delineated unit” that also includes Burial 32 (a superannuated, 55+ years old man) and Burial 44 (a 3-9 year old child). This young woman appears to have died while resisting a person or persons with access to firearms.

Trauma at the ABG shows a unique pattern relative to other sites in the number of perimortem fractures. At Catoctin, there are a few minor antemortem fractures in a wrist (distal radius), ulna, clavicle, metatarsal, and metacarpal plus a dislocation of a hip and perhaps one shoulder that could easily be related to accidental injury although interpersonal violence is not ruled out. Incidence of fracture is not available from South Carolina. At New Orleans, no perimortem fractures are reported, but three males do have antemortem fractures that are more indicative of violence rather than accidental injury. One male has three cranial fractures that the degree of remodeling suggests were inflicted in at least two different episodes. A second male has healed cranial fractures as well as a healed parry fracture of the ulna and a third male also has a single parry fracture. The ABG does show cranial fractures in both males and females as well, suggesting interpersonal violence. The lack of such fractures at Catoctin may indeed reflect better treatment of skilled enslaved laborers in that location than in eighteenth-century New York.